"Deus ex Machina"
The Introduction of AI to Furniture Design

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Abstract

In Spring 2023, students in our Furniture Design class were asked to design two desks for a small office space in an existing building. Unfortunately, none of the students produced a feasible design solution. The reasons we identified were deficiencies in design history, English, math, and general problem-solving, but mainly a lack of elementary skills in sketching. Students failed to use the right tools and techniques, which hindered them from finding proper answers to the design problem. Therefore, we opted for a dramatic change in our teaching methodology. As a fortunate coincidence, it happened that at this time the deus ex machina emerged, and "a seemingly unsolvable problem ... was suddenly ... resolved by an unexpected and unlikely occurrence" [1]. Exactly 68 years after the Dartmouth workshop [2], Artificial Intelligence (AI) tools became available to the profession with the capacity to not only challenge our understanding of how the design process works but also the power to make up for skills our students failed to acquire. But rather than asking if it is the machine or the human who designs in these new scenarios, we merely focused on the question of how we can use AI to assist our students to mature in their design disciplines. Reference objects [3] played an important role in this endeavor. But instead of photos of real objects, we used Midjourney - an AI image generator - to create images of objects that did not exist beforehand but were concrete answers to the design problem. Through a critical discussion of the pros and cons of the AI-generated output, our students formed an understanding of these objects, which then became cases, "... a contextualized piece of knowledge, an interpreted representation of a real experience…." [4]. Students then used these cases to develop the solutions further. The attempt to enable these students to develop feasible solutions using AI-software in conjunction with traditional tools and techniques was extremely successful. And in this regard, it is indeed fair to say that we can be rest assured that no student who used these tools once, will revert to traditional methods in the foreseeable future.

Keywords: *Artificial Intelligence, Midjourney, Design Education*

1. Introduction

At the beginning of the Spring Semester of 2023, we sought collaboration with a well-known institution in Abu Dhabi, to provide our students with a more realistic work experience and to gain some attention regarding our capabilities in the digital fabrication of furniture items. The task that was agreed upon was the re-design of a small office space at the end of a hallway in one of their buildings. Students were asked to design two desks/workbenches as furniture items and to complement the furniture design with the re-design of other elements such as the walls and the floor. The development of a complete, comprehensive solution for how this space can be re-used and furnished was required. Unfortunately, due to deficiencies in English, math, and general problem-solving, and mainly a lack of elementary skills in sketching, students failed to use the right tools and techniques, which in turn hindered them from finding proper answers to the design problem.

With that being said and knowing that students in the Furniture Design class also needed to manufacture the design objects with the aid of CNC machinery, it became obvious that a change in teaching methodology was necessary. As a fortunate coincidence, we came across publicly available generative AI-tools with the capacity to not only challenge our understanding of how the design process works but also with the power to make up for skills our students failed to acquire. The results are convincing, thought-provoking, and worrying at the same time.

2. Course Methodology

The course is structured in three blocks. The first block serves as a general introduction to form an understanding of furniture in general. Following this, comes a second block where the actual design work is conceptualized, sketched, and drawn. In the third block, students create digital 3D Models of the furniture items and produce these with CNC machinery.

Common Methodology	Revised Methodology
Warm-Up Sessions	
Ad-Hoc Design	
Conceptual Design Sketching	Conceptual AI Prompt Writing
Pre-Design Drawing	Applied AI Prompt Writing
Detailed Design Drawing	Refined AI Prompt Writing
Digital 3D Modeling	
Digital CNC Fabrication	
Manual Finishing	

Table 1: Course Methodology

2.1 Warm-Up Sessions, Ad-Hoc Design

The Warm-Up Sessions are a methodological attempt to understand the capabilities and deficits of a particular student cohort to better guide them through the design process. Every student cohort might have different challenges or deficits, and it is imperative to understand these to amend the existing course structure to suit that specific cohort's needs. Structural, ergonomic, as well as aesthetic considerations for the design of furniture are discussed and evaluated in short ad-hoc design sessions. An example of such a design task was the re-design of an on-campus meeting room. Students had two hours for this task, and any design intervention they might have found useful to improve the current status quo of the room was welcome. The outcomes were worrying. A lack of understanding of scale and dimension, major problems of addressing the design task in a short period, and nescience of precedents led to insufficient results.

2.2 From Traditional Design Sketching to Case-Based Reasoning

The conceptual design phase is characterized by intensive sketching and problem-solving. It is the phase with the highest influence on the later design proposal. In the Concept phase for the office project, we asked students to develop initial ideas for the general layout of the space. They needed to create conceptual sketches and pre-designs and build a model of the furniture located in the hallway of the office. The initial outcomes were on a similarly low level as the results of the Warm-Up, and only after the first desk crit students began to revise some of their tools and created more appropriate analytical sketches. However, the quality of those still rendered it difficult to develop acceptable design solutions that students could build later during the semester. Oftentimes plans, sections, elevations, and models showed different content. Since no coherent pre-designs were developed that could pave the way for sophisticated, buildable design solutions, we decided to introduce a new methodology, which allowed us to generate images of the furniture based on a textual description. When we introduced these AI-tools to the classroom we needed to make sure students got a good understanding of the basic ideas and history behind Artificial Intelligence. An introductory lecture to the AI-image generator Midjourney and the Chatbot Discord was conducted. Both applications were also installed on the students' laptops. We were aware that with the recent introduction of Artificial Intelligence into the design disciplines, powerful tools emerged that challenge our understanding of the design process. At this point, it was challenging not to delve into a discussion about the ethical application of AI, since we aimed to simply make up a deficit and concentrate on introducing a tool with the potential to assist students in design development. Our methodology was built around "reference objects" such as those described by Richter [3]. They were, however, different from how they were envisioned in the past. In the Cognitive Sciences, the Dynamic Memory Theory describes remembering, understanding, and learning as inseparable processes [5], and "Analog Reasoning" as a method of concluding based on similarities between things, objects, or phenomena. Professional designers constantly make use of this method. It is part of their everyday work to evaluate existing designs and draw conclusions for their projects based on similarities with other designs. Their professional experience makes this course of action possible. Students do not have this experience yet and must rely on sources such as books, magazines, or the few projects they have been

introduced to by professors at the university. The experience gained from these projects most often entails success, but indeed also failure, i.e. problems. In Artificial Intelligence, “Rule-Based Reasoning” uses generic models and rules to describe such problems, whilst in “Case-Based Reasoning (CBR)”, a different paradigm of AI, experiential knowledge is used that is represented in cases. These “Cases or Reference Objects” consist of a description of the problem, solution, and result. A solution might not necessarily always reflect a good result. Failure is part of CBR since learning from failure is an important aspect of the underlying cognitive theory. Generative AI-tools such as Midjourney generate images, that can serve as reference objects, and through expert analysis, can turn into cases, that form the basis for understanding. In other words, the main problem with the introduction of AI-based image generators creating project solutions, i.e. reference objects, is that students lack the necessary experience or expertise to judge the solution. Whilst failure is generally an important aspect of the process since it creates understanding, provided the triad of problem, solution, and result exists, students might not always be able to differentiate success from failure. However, reference objects also serve different purposes [3], and whilst their role as a source of design constraints and for design evaluation might be left to the experts, they can simply also function as a source of inspiration and a means of communication.

2.3 Design Drawing versus AI Prompt Writing

The results of the conceptual designs generated by the students using traditional means were immature and by no means on the level needed for the subsequent digital fabrication of the benches. Too many missing skills resulted in a methodology change, where we replaced pen and pencil with the written word and inserted these words (prompts) into an AI-based Image Generator, which then produced the desired output in no time. Midjourney was extensively used to generate diverse images in the form of reference solutions that could then be interpreted in the classroom. By using the “imagine” command in Midjourney students described what the Interior Design solution (or any other) should entail. The program usually needs less than a minute to generate the respective output. Should the student decide to re-run the command without using different parameters, a new image is generated. These images, respectively design solutions, are created from scratch. They are neither copies of existing design solutions, nor are they built through image compositing of elements found in existing images. But they do entail aspects of images/solutions that the Machine Learning algorithm in Midjourney captured through image analysis. The interesting part of this process is that it appears as if these generative AI-tools do not only have awareness but also understanding. As such, they are aware of specific demands or problem domains and generate solutions to address these problems, i.e. the cross-bracing of a bar stool´s legs that would otherwise be instable. Such functionality has never been seen in Computer-Aided Design systems before. Prompt writing and refining the prompt output through prompt adjustment (engineering) is a process much like the traditional sketching process during the Pre-Design Phase. Designers design and re-design and whilst it appears that they create more and more solutions, they merely restrict the space of possible solutions to get closer to an optimal result.

Figure 1: Imagine Prompt: **"**Modern glass living room area with curved sofa and furniture and Japanese architecture integrated with Japanese garden view", Fawaghi Al-Shaikh

Figure 2: Imagine Prompt: **"**Modern glass living room area with curved sofa and furniture and Japanese architecture integrated with Japanese garden view", Fawaghi Al-Shaikh

2.4 Refining AI

After the first stage of design development, we asked students to analyze and refine the solutions generated with the AI system. Interestingly, some students used traditional techniques of printing and sketching on transparent paper to revise the designs. Not all designs were feasible and the reasons for it were manifold. A lack of design language, deficits in the use of English, an insufficient amount of time spent on prompt engineering, and indeed drawbacks in the AI system. However, most of the solutions generated were simply stunning and built a fantastic repertoire of designs to be developed further. It was interesting to see that students used quite simple initial prompts, that had only a few or no spelling or other language errors. Despite these short prompts, the system produced appropriate output anyway. Major hurdles appeared when students went into a lot more detail in prompt writing but used non-sophisticated descriptions of materials, dimensions, or other properties of the potential design solution. These outputs usually did not match too well with the original description. It became clear, that prompt engineering - as much as Interior Design - is still something that needs to be learned properly and might have the potential, if not to replace, but certainly to complement the traditional approach of designing and re-designing on paper.

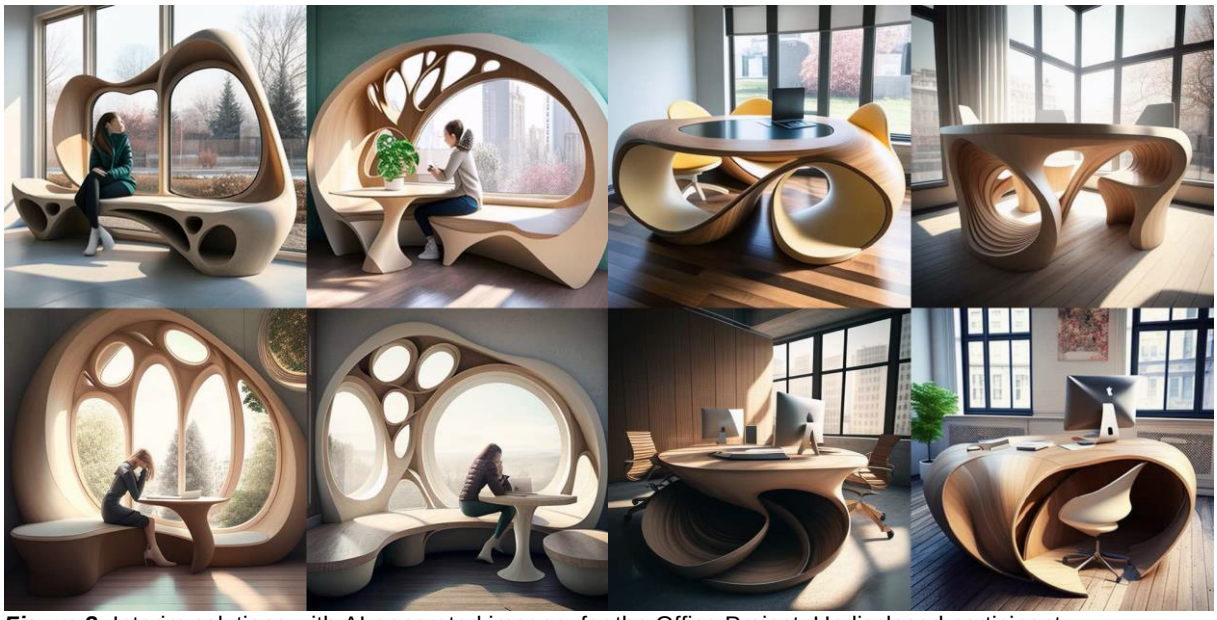

Figure 3: Interim solutions with AI-generated imagery for the Office Project. Undisclosed participant.

2.5 Digital Fabrication and Manual Finishing

Digital fabrication techniques became the standard tool in the Furniture Design class more than half a decade ago. The introduction of new students to the tools and techniques is seamless. Because of the delay at the beginning of the course, we had to change our course of action and let all students work simultaneously on all projects, trying to make up for the time that was wasted. The best solutions were being 3D modeled, CNC´ed, and manually assembled and finished.

Figure 4: Digitally fabricated bench for the Office Project, Undisclosed participant.

Figure 5: Digitally fabricated bench for the Office Project, Undisclosed participant.

2.6 Course Observations and Findings

These are indeed preliminary findings for that course only, since it was the first time that we introduced generative AI. We are in the process of evaluating the solutions developed with the aid of the AI system. These are promising and beyond anything we would have ever expected from such a system. Constructing these solutions in 3D is indeed the next challenge to expedite the production and fabrication process. However, we are well aware that AI-based 3D modelers are already under development, and this leads us to the conclusion that the design and construction process in this industry is likely to change. Tool development is no longer a matter of time. Much of it is there. Ready to be used. And better than anything we had ever imagined. The consequences are dramatic and need a profound academic discussion not only about tools but also about their professional and societal impact.

The profession and respectively education will undergo change. The question is, who calls the tune?

3. Conclusions

Observation 1:
In the Spring Semester of 2024, we taught the same class and had similar experiences. Students' abilities to sketch, draw, and think analytically deteriorate. A Summer class with High School students showed similar results. Manual techniques are decreasing, whilst we see a growing affinity toward the digital. Unfortunately, not often in conjunction with skills. According to our observations in the University but also the school, basic but essential skills in IT are missing.

Observation 2:
A real hype started evolving around generative AI-tools, and professionals as well as students seemed to have little issues adopting AI-systems that were in this form previously impossible to be introduced to the discipline [6]. A recent study revealed that AI has marginally or highly accelerated the design process of 88% of the participating designers (architects), and 75% of the participants believe that AI has the potential to drive innovation in architectural design [7].

Observation 3:
Authorship and respectively ownership was and still is an aspect in generative AI-Systems that is widely debated. We did not see any indication of such issues with the students. For them it was crystal clear that these designs were theirs, no matter that they were well aware that the basis for the generative process was not based on their design expertise and repertoire, but merely on their description of an idea, that was then generated on the expertise of others, brought together through the generative system.

Observation 4:
Generative AI-Systems appear to be less vulnerable toward improper spelling than expected. Even prompts with language snippets that hardly made a complete sentence produced usable results. In most cases, the generative software also extended the task toward walls, ceilings, or floors that were integrated into the solution and produced valuable ideas for the further development of the designs.

Figure 6: Variants of tables. Undisclosed participant.

Observation 5:
Solutions are not always fully reliable. Simple aspects such as overlapping elements in the designs were common. This does not necessarily mean that these designs weren´t possible to be built, but they would most likely be uneconomical. An aspect that is easy to elaborate for a professional, but difficult for a student with limited experience.

4. The impact on education

We are not prepared. The development of (generative) AI-tools, even though 68 years in the making, hit us entirely unexpectedly. After decades during which researchers developed systems, which is fair to say mutually failed, it happened quasi-overnight that systems accessed the market with the capacity to change an entire discipline. Not just Furniture Design, but interior Design, Architecture, and related fields will see a massive influence of generative AI very soon. It is estimated that 78% of architects and designers think that AI will influence the future of architectural design moderately or strongly in the next 12 months, and 88% state that AI will play a significant role in the future of architecture practice as a whole [7].

The influence on education is unforeseeable. Almost every technique and method we have used and taught thus far might soon be obsolete. We showcased that design development in the early stages is one of the primary areas for AI integration, and that image generation in the form of renderings is completely integrated into this task. Respectively, courses in visualization or modeling techniques will be outdated and must be removed from the design curricula. The problem education will face is the ephemerality of the development. AI is not a one-hit-wonder, but it is something that develops so rapidly that it might not be sustainable enough to find its way into the Curriculum the way we were used to. Once integrated, it might already be dated. As such it requires different modes of representation in the curriculum, and it requires us to generally rethink (design) education.

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